

RAMAN SPECTROSCOPY AND MICROSCOPY

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Introduction

The Newest Raman is Truly Amazing

Raman spectroscopy is rapidly receiving a great deal of attention. This is due to the fact that within only the last few years the imaging capabilities have improved dramatically and its applications have also expanded a great deal. Nonetheless, there are still a large amount of people who do not even know what Raman spectroscopy is and how it can be used. This pamphlet introduces, in an easy to understand manner, the basics of Raman spectroscopy and just what makes it so amazing.

What does Raman
spectroscopy measure?

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This is
the Raman spectrum

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Four things
the Raman can tell us

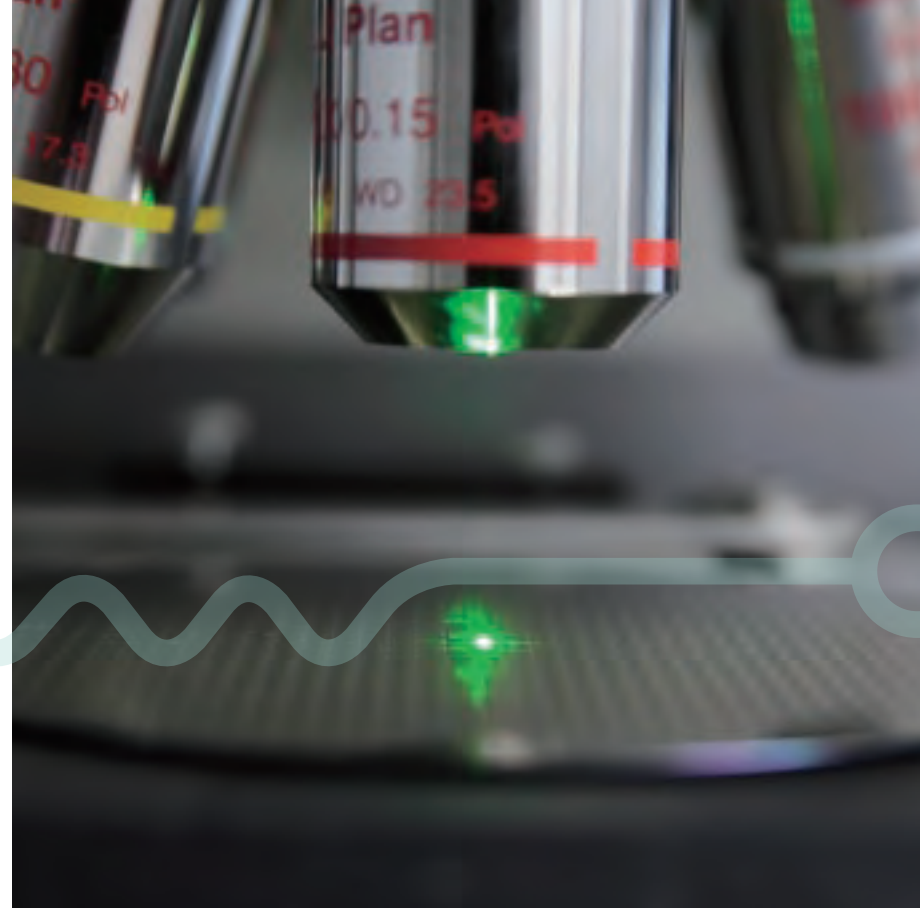
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Let's Start
Surface Analysis

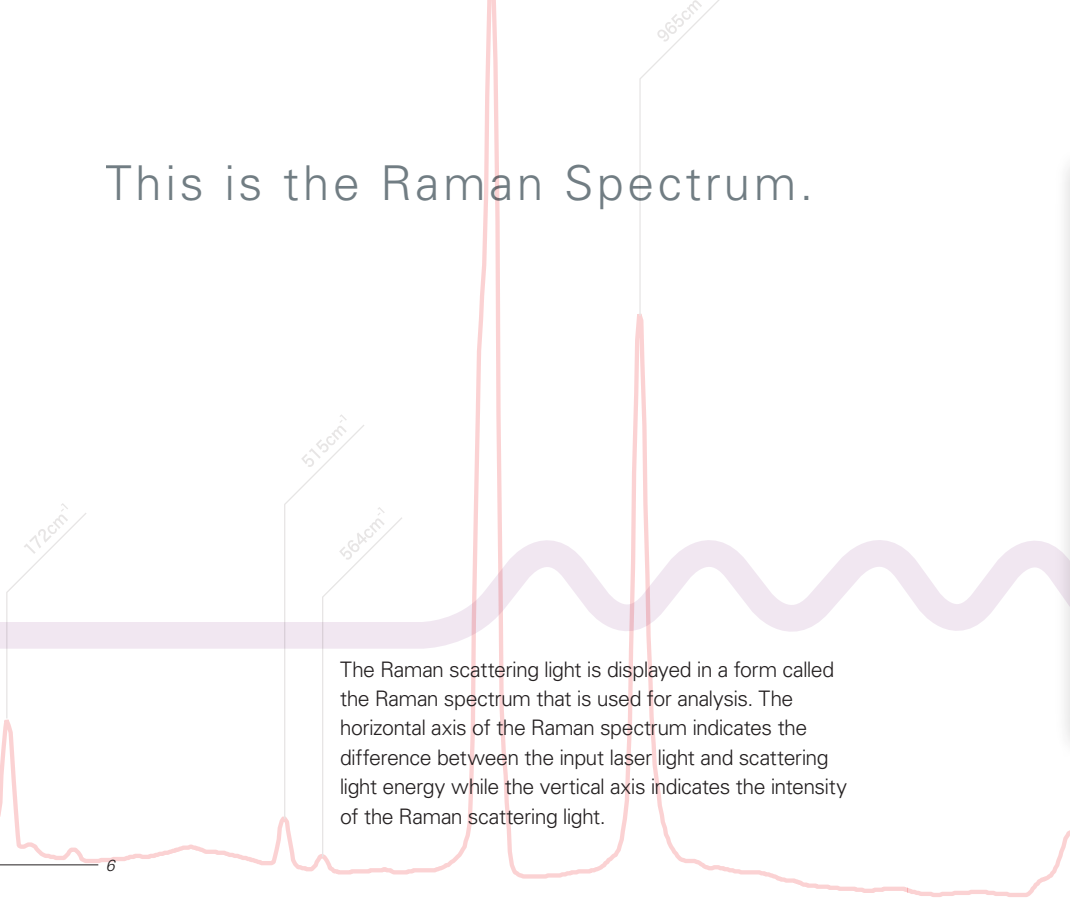
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What does Raman spectroscopy measure?

A test piece is exposed to a laser such that a scattering ray possessing slightly different energy than the laser is emitted. This is called the Raman scattering light and its amount is extremely miniscule. Raman spectroscopy is able to measure this weak light in order to analyze the molecular structure of the test piece.

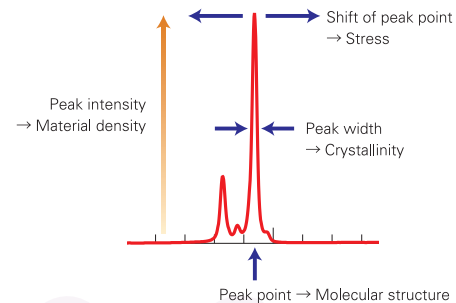


This is the Raman Spectrum.



The Raman scattering light is displayed in a form called the Raman spectrum that is used for analysis. The horizontal axis of the Raman spectrum indicates the difference between the input laser light and scattering light energy while the vertical axis indicates the intensity of the Raman scattering light.

Easy Guide to Reading the Data



The Raman spectrum includes various peaks derived from the molecular structure of the test piece. The molecular structure is analyzed according to the characteristics of these peaks. What, then, does an analysis of the Raman spectrum allow us to understand specifically?

I want to know about this!

Q

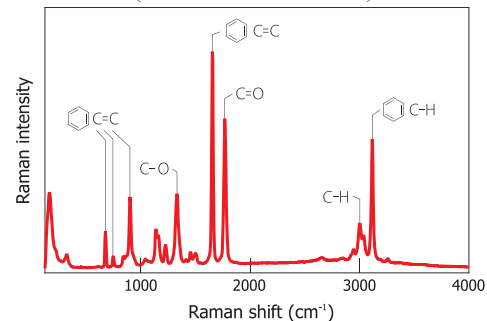
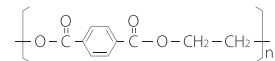
What does Raman spectroscopy tell us?

A₁

By looking at the Raman peaks, we can understand the elements of the chemical bonds that configure the test piece.

PET Raman Spectrum

Structural Formula of Polyethylene-Terephthalate (PET)



The functional groups and other elements in the molecular structure are indicated by peaks at specific points. By attributing these peaks, we can understand what kind of chemical bonds are included in the molecular structure.

I want to
know about
this!

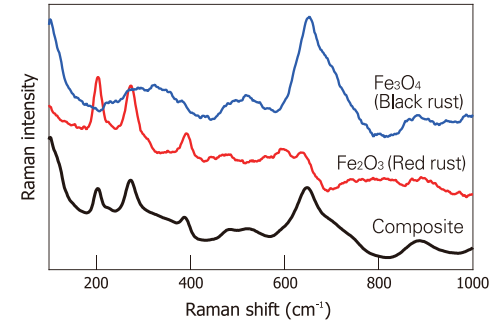
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What does Raman spectroscopy tell us?

A₂

The Raman spectrum waveform allows us to identify the composition of the test piece.

Raman Spectrum of Rust



Each substance has its own specific Raman spectrum. If a spectrum possesses peaks for both black and red rust, then the test piece can be identified as a composite of both substances.

I want to
know about
this!

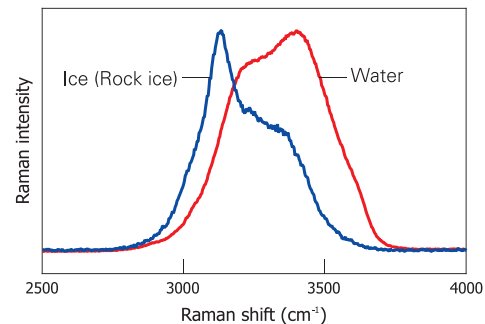
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What does Raman spectroscopy tell us?

A₃

The Raman peak width and polarization properties allow us to identify the orientation and crystalline structure of the test piece.

Spectrum Variation due to Water State



A substance with the same molecular formula can have different Raman spectrum shapes due to the state of the orientation of its molecules and crystalline structure. For example, ice and water can be classified by different spectra.

Stress Measurement of Silicon

I want to know about this!

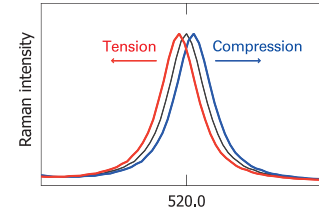
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What does Raman spectroscopy tell us?

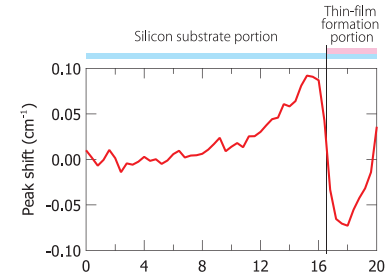
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The amount of shift of Raman peak points allow us to determine the intensity and orientation of stress within the test piece.

Relation of Silicon Peaks and Stress



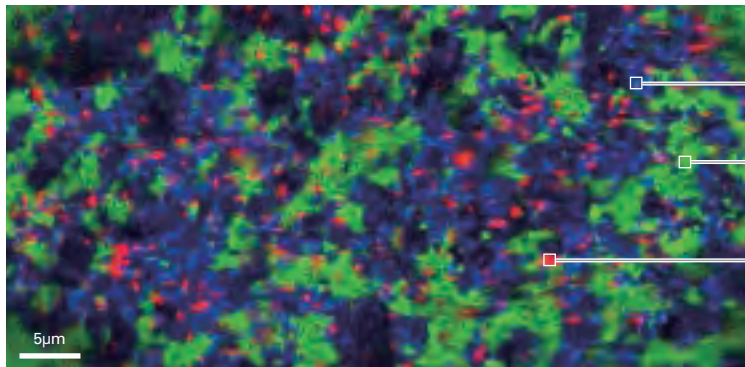
Sample Measurement



Applying force to a crystal breaks up the atomic configuration which is then expressed by the shift of the Raman peak point. From the sample measurement shown on the right, we can understand that stress is being applied near the thin-film formation portion.

' Raman Imaging": A New Function

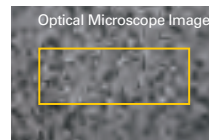
Let's Start Surface Analysis



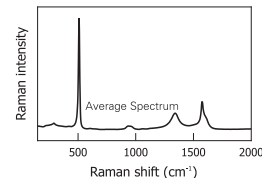
Excitation wavelength: 532 nm Objective lens: 100x, 0.90 NA Image pixels: 400 x 150 pixels
Measurement range: approx. 80 x 30 μm Measurement time: 27 minutes

Until now, Raman spectroscopy has only been able to perform single-point analysis. However, this has now changed. The ability to measure a certain range on a test piece in a comprehensive manner allows us to observe the distribution of components and stress in the form of an image.

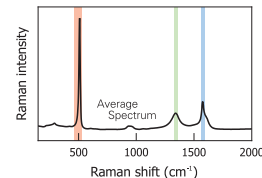
Actual procedures are as shown below:



The measurement range is specified to perform comprehensive Raman measurement.

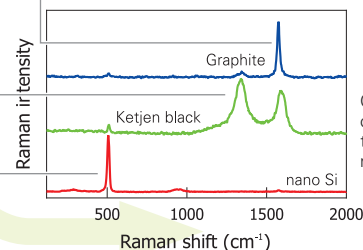


First, the average spectrum of the entire measurement range is checked.

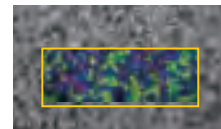


The peaks that require further attention are assigned different colors...

Abstracted Single-Component Spectrum



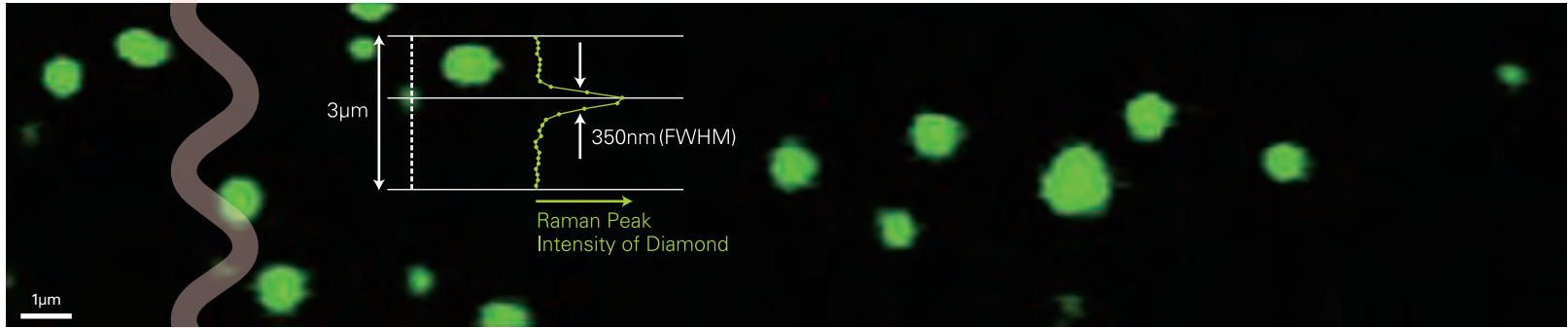
Component elements can be identified by the spectra of the microscopic region.



The intensity distribution of each peak can be observed according to the corresponding color.

The Raman peaks of diamonds are assigned green to provide imaging of intensity distribution. The profile of the peak intensity shown by the dotted line indicates that the full width at half-maximum (FWHM) is 350 nm.

Raman Imaging of Diamond Beads



Excitation wavelength: 532 nm Objective lens: 100 x, 0.90 NA

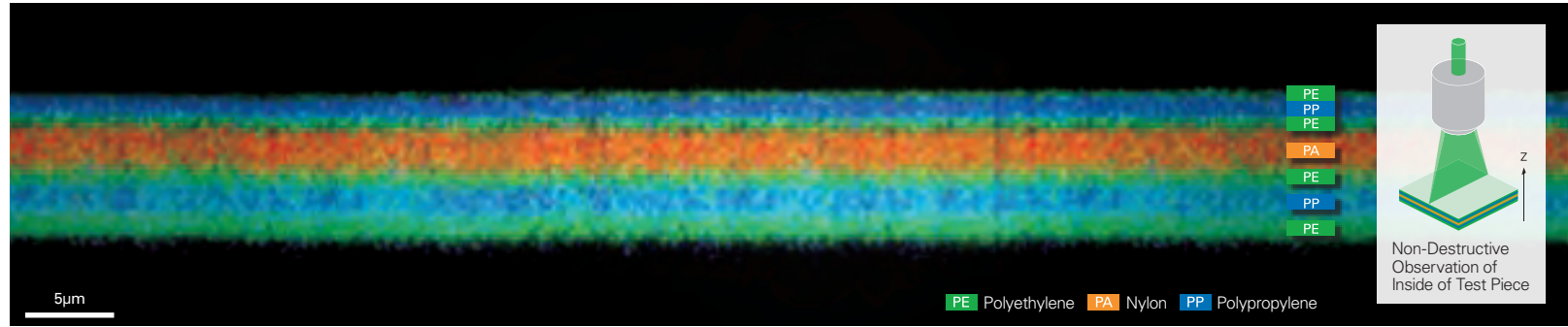
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Spatial Resolution of 350 nm

View the Distribution of Tiny Elements

One strength of Raman microscopes is that laser emission can be narrowed down to a very small size, providing a spatial resolution of nearly 350 nm in the planar direction. This allows for the ability to see each single diamond bead having a diameter of approximately 350 nm.

Imaging of Multi-Layer Membrane Film



Cross-sectional Raman imaging of wrapping film for foodstuffs. Assigning specific colors for the peaks of nylon, polyethylene and polypropylene allows us to see the multi-layer membrane construction.

Excitation wavelength: 532 nm Objective lens: 100 x, 1.40 NA, Oil

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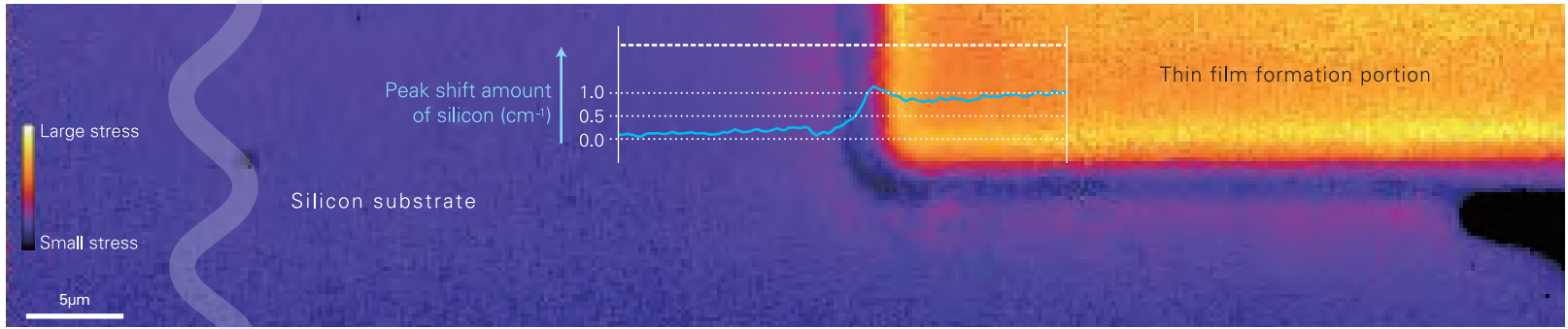
Non-Destructive Observation of Inside of Test Piece

View a Cross-Sectional Image of Multi-Layer Membrane

Use of a Raman microscope featuring a confocal optical system allows for imaging without having to cut a transparent test piece. The use of a high-NA oil-immersion objective lens allows for the detection of layers that are only a few hundred nanometers in thickness.

The Raman peak shift amount of Silicon is displayed in color. The profile of the peak shift amount shown by the dotted line indicates that stress is being applied to border region of the thin film of the silicon.

Stress Distribution Imaging of Silicon Substrate Surface



Excitation wavelength: 532 nm Objective lens: 100 x, 0.90 NA Diffraction grating: 2,400 gr/mm

R A M A N I M A G I N G 0 3

Measure Localized Stress

View Microscopic Stress Distribution

Displaying the shift amount of the Raman peak point in color allows us to create imaging of the stress distribution. Utilizing the high spatial resolution of the Raman microscope allows us to observe microscopic stress distribution at a pitch of a few hundred nanometers.

We hope this has provided you with an
understanding of the new-generation Raman.
We hope that it will be useful in your own research.

